The Effects of Aggregation and Disaggregation on Particle Size Distributions and Water Clarity in the Coastal Ocean

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LONG-TERM GOAL

The long-term goal of this research is to develop tools to quantitatively predict the effect of fine siliciclastics on water clarity in the coastal ocean. Scattering of light by suspended particles depends on sediment concentration, composition, and size distribution. Particle size distributions in coastal waters are dynamic because high concentrations of suspended sediment in coastal waters favor frequent encounter between particles. These encounters lead to the formation of large macroaggregate particles, or flocs, with diameters greater than 0.5 mm. While aggregation modifies the size distribution by building larger particles, variable and energetic turbulence in coastal waters can modify the size distribution by disrupting aggregates. Predictive knowledge of scattering depends on understanding of the conditions under which aggregation and turbulence-induced disaggregation alter the size distribution and of the form of the size distribution that these processes combine to produce.

SCIENTIFIC OBJECTIVES

This research has three primary objectives. The first is to observe spatial and temporal variability in macroaggregate size distributions in situ in the bottom boundary layer (BBL) at the Coastal Mixing and Optics field site. The second is to relate observed size distributions to small particle size distributions, turbulent kinetic energy (tke), and optical properties in the BBL. The third is to extend BBL aggregation models to conditions of unsteady flow.

APPROACH

Time-series photographs of macroaggregates have been taken with a bottom-tripod-mounted floc camera on the continental shelf in the mid-Atlantic Bight during ONR's Coastal Mixing and Optics deployment. Data synthesis involves comparison of in situ macroaggregate size distributions with small particle size distributions generated with an in-situ, laser particle sizer (LISST) deployed on the same tripod as the camera (Agrawal, Sequoia), with turbulent kinetic energy dissipation rate measurements made on a nearby tripod (Trowbridge, WHOI), and with optical properties monitored in the bottom boundary layer nearby (Boss and Zaneveld, OSU).

WORK COMPLETED

A manuscript describing destruction of macroaggregates during storms was accepted for publication in a *Journal of Geophysical Research* special volume on the Coastal Mixing and Optics experiment. The relationship between magnitude of the attenuation coefficient and the slope of the attenuation spectrum observed by Boss and others (JGR special volume) was investigated with two models of particle size in the bottom boundary layer. The first model used bed sediment size distributions to predict particle size as a function of height and boundary shear stress. Particle sizes were converted to time- and depth-dependent attenuation coefficient with Mie theory. The second model used a simple parameterization of particle aggregation and disaggregation to predict size distribution as a function of concentration in a well-mixed box that was undergoing sinking losses.

RESULTS

Data on macroaggregate size distributions, waves, and currents indicate that turbulence does not strongly influence macroaggregate size when tke is low to moderate, but that macroaggregates are destroyed under energetic forcing. This result suggests that forces other than turbulence, namely those applied to macroaggregates during sinking, limit macroaggregate size when tke is low to moderate. This hypothesis explains why measured macroaggregate settling velocities across diverse environments are so uniform.

The relationship between attenuation and the slope of the attenuation spectrum observed by Boss and others was not well explained by the model that distributed bed sediment throughout the boundary layer with no repackaging of particles. The relationship was remarkably well explained by the simple aggregation-disaggregation model. This result suggests that the slope of the attenuation spectrum may be a useful metric of the degree of flocculation in a suspension.

IMPACT/APPLICATION

Fine sediment suspensions can likely be treated as a two-state system. When tke is low to moderate, the majority of suspended mass is contained in macroaggregates that sink at speeds of 1 mm s^{-1}. When energy levels are high, macroaggregates are destroyed. Further work with Agrawal will clarify the fate of destroyed macroaggregates.

A simple parameterization of aggregation and disaggregation is effective for predicting optical properties of concentrated inorganic suspensions in boundary layers. This result suggests new ways for monitoring flocs, and it indicates that the essential features of an aggregated suspension can be captured with a relatively simple model.

TRANSITIONS

The camera technology developed in this study has been adopted in part by Syvitski for construction of a DURIP-funded floc camera.

RELATED PROJECTS

With NSERC (Canadian) funding, the spectral response of optical backscatter to particle size distribution is being explored. Collaborator is Jon Grant (Dalhousie).

PUBLICATIONS

Hill, P. S., G. Voulgaris, and J. H. Trowbridge (in press). Controls on floc size in a continental shelf bottom boundary layer, *Journal of Geophysical Research,* in press, September, 2000.

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